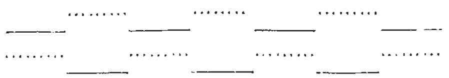
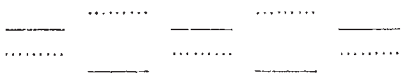
step," do exactly the opposite, that is, place the *opposite* feet forward simultaneously; we then have the following formula:—



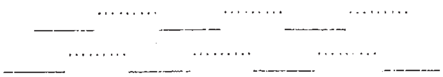
All will recognise this as the "trot" in the horse; although, as M. Marey has proved, there is always, in the true "trot," an interval between each of its two elements, during which all the feet are off the ground at once, thus:—



the upper of the last two formulæ, however, represents the walk of the elephant exactly.

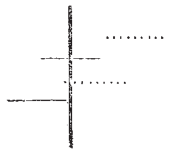
In the amble and the trot, therefore, each complete series of steps is formed of two parts which never overlap; it follows that the sounds produced by them are double also.

The walk of the horse is a phenomenon a little more difficult to realise at first sight. Again referring to the two men, suppose that they walk quite out of step, as it may be termed, in such a way that the front one *has raised* his right leg at the same moment that the hind one is *just raising* his, although they keep to the same number of steps. Such being the case the sequence of the steps would be *right front*, *left hind*, *left front*, and *right hind*, which is the order of succession in the horse, and may be represented thus:—



In this formula it is seen that at no time are there more than two feet on the ground at the same moment, and M. Marey states that in his numerous experiments such is always the case, except when a load is being taken down an incline in a wheeled vehicle, on which occasion three feet may be on the ground simultaneously. In the walk of the horse there are therefore four sounds produced in each complete series of steps, and these four are at equal or nearly equal intervals of time.

We are now in a position to judge of the accuracy of Miss Thompson's delineation of the "Roll Call horse," which is represented walking, with the left fore-foot fully raised from the ground, whilst the others are on it. The right fore-leg is nearly perpendicular and not bent; that is, about half-way between the commencement and the end of its step. The left hind-foot is somewhat in front of the perpendicular axis of the leg; that is, has just commenced its step; and the right hind foot, though on the ground, is on the point of leaving it. As the animal is walking, the lengths of the steps and of the intervals must be represented, as shown above, as of equal duration, and the following is its expression, the thick vertical line representing the moment at which the painting figures it:—



By comparing this with the formula of the walking horse, given above, it is evident that the representation is correct, except in a very slight point, which is that the right hind leg is on the ground, though just on the point of leaving it, whereas it ought to be just off it, because in walking there are never more than two legs on the ground at the same time. The general direction of the legs is quite correct. If the animal had been "ambling," the left hind-foot would have been off the ground, as well as the left fore. It is quite impossible to mistake the "walk" for the "trot," if their formulæ are compared and the positions at any given time worked out from them.

A. H. GARROD

CARPENTER'S "MENTAL PHYSIOLOGY"

Principles of Mental Physiology. By W. B. Carpenter, M.D., F.R.S. (Henry S. King & Co.)

THE title of the volume before us shows that its author is one of those philosophers—happily, an increasing number—who refuse to treat the phenomena of mind as though they were in no way connected with the body through which they find their expression. Mental Physiology is a comparatively new science, and does not date further backward than the days of Hartley. Before his time, and to some extent since, Physiology has been treated from what—to employ a word too often pressed into the service of a somewhat hazy idea—may be called the metaphysical point of view. The phenomena of mind have been abstracted from all their surroundings, and have been analysed by themselves, and the result has naturally been that we have been left but little wiser than before. Dr. Carpenter rejects this method, and bases his Psychology on the construction and working of the nervous system. But while shunning the metaphysical treatment of the subject, he does not adopt the other extreme, the doctrine, we mean, of the thorough materialist, who regards all mental phenomena without exception as the outcome of previous physical causes, which necessarily produce certain results. He steers a middle course, inasmuch as, while he advances the theory "of the dependence of the Automatic activity of the mind upon conditions which bring it within the nexus of Physical Causation," yet he believes in "an independent power, controlling and directing that activity, which we call Will."

This doctrine of the independence of the Will is the distinguishing characteristic of Dr. Carpenter's philosophy in the book before us; it runs through the entire work as the one grand exception among a series of physical sequences, interdependent, and standing to each other in the relation of cause and effect, of antecedent and consequent. Yet, even to a mind which is not "trammelled by system," this splendid anomaly may seem strange and surprising, though the prevalence of the belief in a Free Will, even among scientific thinkers, need cause no wonder, so long as the ethical bias is not rigidly excluded from psychological speculation. It is the meritorious timidity of the moral side of human nature which says, "whatever else may be under laws of necessity, the Will at least is free and independent, for the alternative doctrine deprives all actions of their moral value, and reduces man to the level of a mere machine."

It is clear that Dr. Carpenter is not satisfied with the doctrine of the so-called necessarian school indeed, he quotes Mr. Mill's Autobiography in his preface to show that the great necessarian himself wavered in his belief. He clearly thinks the explanation of human conduct offered by those who reject the theory of the independence, or rather the self-dependence, of the Will, inadequate. They would say that the unconscious operation of causes proceeds independently of the conscious conviction of the individual; that however much we may think that of two lines of conduct before us, either is equally possible for the human Will, yet, as a fact, we invariably follow the one to the exclusion of the other; the result, as it were, proves the cause, the apparent ultimate choice is the real physical consequent of antecedents engrafted in our nature, and acting in an invariable sequence, though it is true, as shown by Mr. Mill in the sixth book of his Logic, that Science is not sufficiently advanced to enable us to predict successfully the course of human action in any case, owing to the much greater complexity of the influences which operate in determining sociological phenomena when compared with other forms of activity. The necessarian philosopher would say that the operation of the Will is really nothing more than the force of the stronger motive asserting itself. Dr. Carpenter, and with him is the majority of mankind, says that the Will itself determines from within us which motive shall be the preponderating one.

But the chief merit of Dr. Carpenter's book lies, as we have said, in the explanation of the nexus which binds together the physical and the psychical elements in human nature. The well-known authority of what he says on such a subject constitutes the main value of his work. It is not too often that a great physiologist has turned his attention to mental phenomena, and we therefore welcome all the more gratefully any addition to the number of those who base their psychology on an exhaustive analysis of the functions and modes of action of the nervous system. In the first and second chapters of his book—the backbone, if we may so call it, of the work—Dr. Carpenter unravels carefully and exhaustively, step by step, all the interdependences of the nervous system and the psychical states. Without entering on all the mysteries of nervous ganglia and afferent and motor fibres, or the physiological comparison of Articulata and Vertebrata, we would say generally that Dr. Carpenter divides bodily movements in man into three classes:—(1) The primarily automatic; (2) the secondarily automatic; and (3) the volitional. Of these the first two "are performed in respondence to an internal prompting of which we may or may not be conscious, and are not dependent on any preformed intention, being executed 'mechanically'; while the last are called forth by a distinct effort of Will, and are directed to the execution of a definite purpose." But though thus clearly laying down the doctrine of the self-determining power of the Will, the author somewhat qualifies it afterwards, when he says that "even in the most purely Volitional movements the Will does not *directly* produce the result, but plays, as it were, upon the Automatic apparatus by which the requisite nervo-muscular combination is brought into action."

The conclusion at which our author arrives as to the general relations of mind and body is, in his own neatly-expressed words, "that the actions of our minds, in so far as they are carried on without any interference from our Will, may be considered as 'Functions of the Brain.'" These Functions of the Brain and of the Nervous System which supplies the brain with the materials which it works up into sensations and ideas, are lucidly and exhaustively expounded in the second and longest chapter of the work, in which the element of pure physiology preponderates, and into which we do not intend to enter, as no short summary of it can fairly represent its contents. Suffice it to say that in this part of the book Dr. Carpenter shows that the amount of intelligence (not instinct) shown by an animal is in a direct ratio to the relative size of the cerebrum and the sensorium, which latter organ in man is nearly eclipsed by the superimposed cerebral hemispheres, "the instrument of our psychical or inner life;" that the cerebrum is not concerned in the ordinary performance of our automatic movements, though in many cases it exercises control over them; its power, however, does not extend so far as to enable it to interfere with "the nervous system of organic life," or sympathetic system. The ruling monarch here at last meets with constitutional checks. It can exert no modifying influence on the "nutritive operations;" they, together with the rest of the sympathetic system, would rather seem to obey another power when they obey at all, the power, namely, of the emotions, which so often rebel against the Will, being, so to speak, the insurrectionary element which breaks in upon the dignified controlling influence of that thinking, purposeful, though sometimes eccentric monarch.

It is impossible in the short limits of a review to enter into the discussion of the part played by Attention, Sensation, Perception, and other physiological conditions in the production of mental results. These are all minutely treated of by our author, who carries us on in an easy progress from one to another with enviable clearness.

In treating of the succession of ideas Dr. Carpenter follows the doctrines of Prof. Bain in relation to the Laws of Association, and acknowledges the debt he owes to that most conscientious philosopher. All students of Prof. Bain's works on Mental Science are already familiar with the Laws of Contiguity and Similarity as explaining the principles of association of ideas, and we need not dwell further on them. The section which deals with Ideo-motor action is very interesting as leading us into the region of the marvellous. Ideo-motor action may be defined to be "the direct manifestations of ideational states, excited to a certain measure of intensity, or, in physiological language, reflex actions of the cerebrum." It is in this definition that we find the true key to the phenomena of table-turning and spirit-rapping, when practised by those who bring no dishonest arts to bear in their experiments. From this definition we should deductively infer that the revelations which reward those who take part in such experiments must be, as is in fact the case, in spite of assertions to the contrary, revelations of some matter known to at least one of the party engaged in the *séance*, whose mental activity and the play of whose ideas, apart from any exercise of Will, may influence the muscular movements *directly* and the more easily, inasmuch as the strained state of the hands on such occasions, after being stretched out for several minutes, renders them the easy and unresisting instruments of the ideational state, intensified, as it is, by the circumstances which surround it. So independent of volition is the influence of the ideational state in these cases, that it often operates in opposition to the dictates of the Will, and the writer has himself seen, more than once, answers extorted, as it were, from a member of a *séance*, unwillingly on his part, simply in consequence of his own highly-strained ideational condition conveying a knowledge through his muscles to those who sat with him at the innocent and obedient piece of furniture. Dr. Carpenter also shows that under this head of Ideo-motor action may be ranged "all those actions performed by us in our ordinary course of life," such as the use of language to express our thoughts, which requires no separate volitional effort, at all events when once we have entered on a train of speech.

But though giving up so large a field of human life to the non-volitional activity, Dr. Carpenter still keeps the Will in view, as a sort of abstract entity, as a "suppositItius," or reserve champion sitting in wait, ready to step in if occasion should call. "The dominant Idea *determines* these movements, the Will simply *permitting* them."

We can give in a few words a summary of Dr. Carpenter's theory of the relation of the Emotions to the Will. He begins by saying that "the Will has no *direct* power over the emotional sensibility," it can only operate to withdraw the attention from the emotional state and fix it determinately upon some other object. Again, the Will "can exert itself in preventing the *expression* of the exerted feelings in action" by suppressing the muscular exhibition of our emotional states; and again, "where the Emotion is not a mere *passion*, but is a state of *feeling* connected with some definite *idea*, the power of the Will is most effectually exerted in withdrawing the mind from the influence of that idea, by *fixing the attention upon some other*"—the power of self-control extends itself from our *impulses* to the habitual *succession of the thoughts*.

We had already learnt our author's views on the relation of the Will to mental and bodily action, but in the middle of his treatise we come upon a full and careful amplification of his opinions on this head, developing his theory of the influence of the Will on the formation of beliefs and on the conduct. We cannot do better than give in his own words Dr. Carpenter's doctrine on the latter head:—

> "To carry into *action* the volitional determination, to give to the 'I will' its practical effect, something more is usually needed than the mere preponderance of motives. The idea of *the thing to be done* (which we have seen to be the necessary antecedent of all volitional action) may indeed be so decided and forcible, when once fully adopted, as of itself to produce a degree of nervous tension that serves to call forth respondent muscular movements, as in the purely ideo-motor form of action. But in general a distinct exertion of the Will is needed to give to the ideational state the energy requisite to call forth the action that expresses it, and this is especially the case where either some powerfully opposing motive diminishes the force of the preponderance, or a state of fatigue causes the bodily mechanism to be less easily called into action."

Hitherto we have been dealing with what the author calls "General Physiology;" we come now to the other division of the work, on "Special Physiology," and the transition is marked by a change of matter and style. We feel that, in reading this latter portion of the book we are being rewarded for the care which is necessary to the mastery of the deeper and more valuable philosophy of the earlier chapters. We have got—we do not speak disrespectfully—out of school into the playground, and we revel in the contemplation of the "morbid conditions" of the mind, illustrated as they are by numerous relevant anecdotes. Mesmerism, somnambulism, and dreaming are all subjects which attract and entertain, especially when treated of by a scientific pen. But we feel that this portion of the work does not call for special criticism so much as what we have already gone through. "Morbid conditions" are very valuable as throwing light on the operation of normal and healthy conditions, but happily the epithet "morbid" is interchangeable with the epithet "exceptional," and therefore we think that the morbid does not require such close treatment as the normal.

Dr. Carpenter winds up his work with a chapter on Mind and Will in Nature, and in it brings to a poetical conclusion what he has so carefully and exhaustively unravelled in the preceding pages.

ANDRÉ AND RAYET'S "PRACTICAL ASTRONOMY"

L'Astronomie pratique et les Observatoires en Europe et en Amerique. Par C. André et G. Rayet. Ie partie, Angleterre. (Paris: Gauthier-Villars. 1874.)

THIS little unpretending volume is of considerable importance. Not only is it the commencement of a series which is intended to include the history of practical astronomy throughout the civilised world, but independently of this, it has claims to notice which are not to be measured by its limited dimensions.

The wide outspreading in the present day of a taste for astronomical observation would lead us to regard with favour anything tending to increase our knowledge of what has been and is being done, especially when it is set before us in so pleasing a form; and we cannot but admit that our neighbours have in this respect got the start of us. Notwithstanding all our efforts to render Science generally intelligible and acceptable, we have not yet succeeded in bringing out such attractive little manuals as proceed from the presses of MM. Gauthier-Villars and Hachette. Our larger and more elaborate treatises may well bear a comparison with anything of a similar calibre produced elsewhere; but in familiar, inexpensive, tasteful manuals, the light artillery, so to speak, of the scientific campaign, we must own ourselves fairly beaten by our nearest neighbours, who have set us a worthy example. We cannot, happily, and if we could we would not, say in this instance, *fas est et ab hoste doceri.* There was a time when such a remark would have been thought appropriate, but "nous avons changé tout celà;" and if such a thoroughly ill-natured and reprehensible observation were to be attempted now, it would meet its ample refutation in this work, which adds to its other merits the charm of courteous and kindly feeling. Next to the cordial abandonment of individual hostility, or the loving, tender reconciliation of alienated friendship, what can be more pleasing than the abatement of national antipathies and the softening down of those asperities which have but too deeply marked the